4. GROUNDWATER

Introduction

The findings of the environmental impact assessment for groundwater for the Mackenzie Gas Project (see EIS Volume 5, Section 4) were based on the following components (see Section 1, Introduction, of this document):

- anchor fields
- gathering pipelines and associated facilities
- NGL and gas pipeline corridor
- infrastructure
- NGTL NWML Dickins Lake Section

The two NGTL pipeline sections, Dickins Lake Section and Vardie River Section, are located in northwestern Alberta. The Dickins Lake assessment was included in the EIS. This EIS supplemental information includes:

- an impact assessment for the Vardie River Section, extrapolating from Dickins Lake Section baseline information
- a combined project effects assessment that includes the Mackenzie Gas Project and NGTL's Dickins Lake and Vardie River sections

See under EIS Summary for a summary of the EIS findings for groundwater.

EIS Summary

Potential effects from the Mackenzie Gas Project on groundwater were expected to start during facility and pipeline construction activities, although some effects could occur during operations (see EIS Volume 5, Section 4).

The effects assessment for groundwater focused on the following valued components (VCs):

- groundwater quantity and flow patterns
- groundwater quality

Effects on groundwater were expected to be of local extent. Most effects will be initiated by construction activities and will result in changes that will persist through, or occur during, the remainder of the Mackenzie Gas Project. Effects that will persist into the far future might be those related to:

- sedimentation
- flow obstruction
- changes in permafrost in the delta
- changes in recharge and discharge related to removing material from borrow sites

Residual effects were expected to cause a change that is within the normal range of variation. No significant effects on groundwater were predicted in the EIS.

Study Areas

The two study areas (see Figure 4-1) used for the baseline and effects assessment were the local study area (LSA) and regional study area (RSA).

The geographic extent of the LSA includes a 1-km-wide strip centred along the pipeline corridor.

The RSA was selected to include groundwater-related features that could be affected by the Dickins Lake and Vardie River sections. The RSA is a 60-km-wide strip centred on the pipeline corridor. Groundwater effects in northwestern Alberta are localized and are well within the RSA boundary.

Baseline

Methods

Data was compiled from literature, air photograph interpretation and fieldwork. Field investigations were carried out along the Dickins Lake Section in late March 2002. Groundwater-related features, e.g., springs, open water and icings, were mapped from the air, upstream and downstream of the proposed watercourse crossings. Twelve watercourses were inspected.

See EIS Volume 3, Section 4 for more information on methods used.

Because of the similarity in bedrock, surficial geology and permafrost conditions between the Dickins Lake and Vardie River sections, groundwater baseline conditions along the Vardie River Section are expected to be the same as those along the Dickins Lake Section. Therefore, field work for the Vardie River Section was not carried out.

Regional Setting

The bedrock geology does not affect groundwater because thick morainal deposits overlie the bedrock. Permafrost in the area is sporadic and discontinuous, and underlies about 10 to 30% of the organic soils in the area.

Most of the Vardie River Section, like the Dickins Lake Section, crosses the Alberta Plateau physiographic region (see EIS Volume 3, Section 4). The terrain is flat with widespread areas of wetlands. A thick cover of glacial till is the dominant surficial material. Sand and gravel lenses often present in the till can form aquifers, but the glacial till and the lack of topographic relief causes shallow groundwater flow to be slow. Groundwater additions to stream flow appear mainly through seepages and occasionally through small springs.

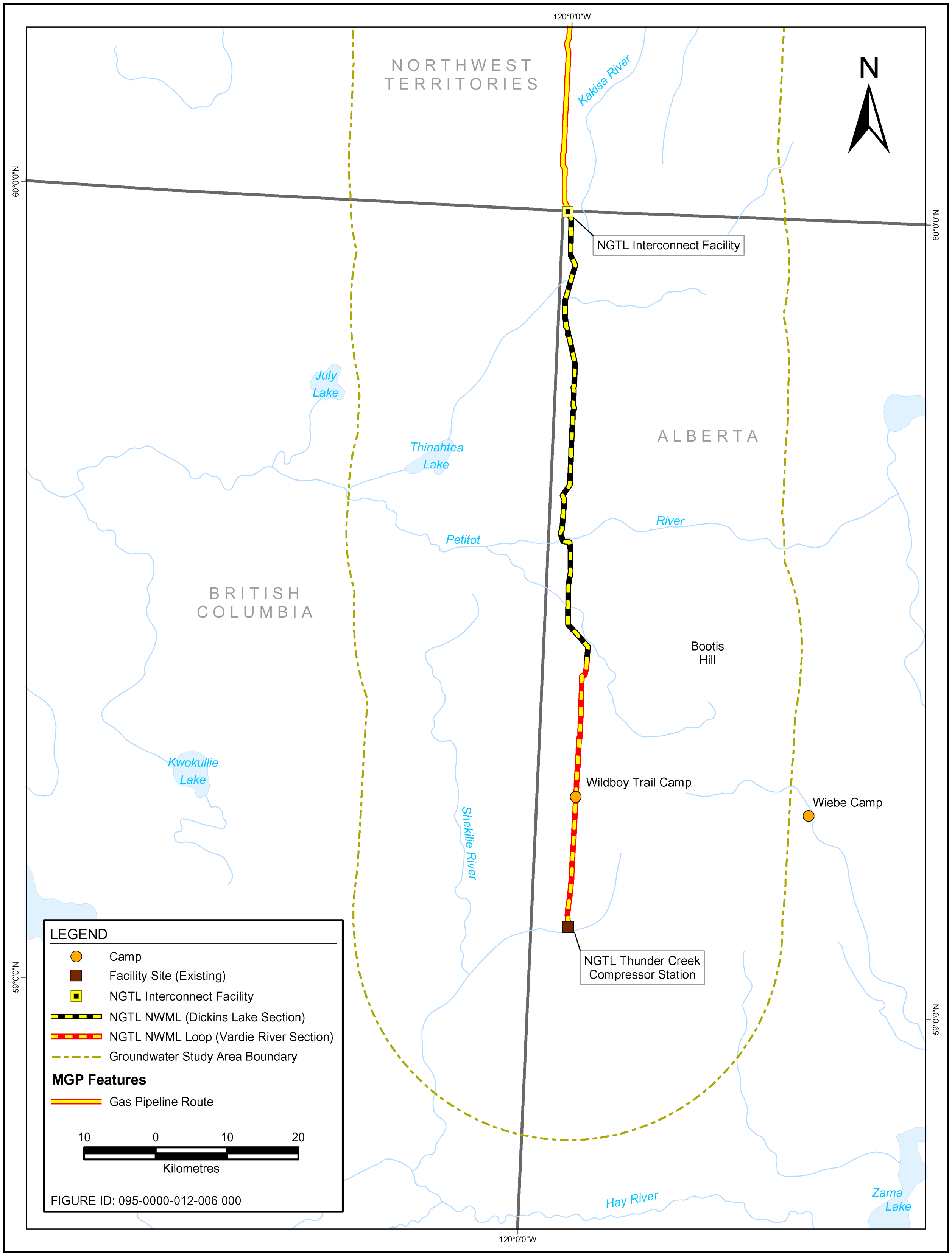

Figure 4-1: Groundwater Study Area

The southernmost 15 km of the Vardie River Section cross the Fort Nelson Lowland physiographic region (Bostock 1970). The Fort Nelson Lowland is a low-lying, poorly drained area with extensive muskeg (Atwater 1994). As in the Alberta Plateau, low-permeability morainal deposits overlie flat-lying or gently dipping Cretaceous shale and sandstone. Shallow groundwater flow rates are expected to be slow in this region.

Most streams along the Vardie River Section, except for the South Shekilie River, are Vegetated Channels, i.e., vegetated drainages with poorly defined flow paths, or with drainage dispersed through shrubs or trees, that are not expected to flow in the winter. The South Shekilie River is an Active I Channel that might freeze only partially to the bottom in winter.

Effects on Groundwater

Effect Pathways

The effect pathway diagram (see Figure 4-2) shows the key pathways and their intermediate pathways, indicating how adding the Vardie River Section could affect groundwater. All pathways are considered applicable except:

- subsidence at Taglu and Niglintgak
- deep well disposal in the anchor fields
- leaks and spills

See EIS Volume 5, Section 4 for a detailed discussion of the effect pathways.

Effect Attributes

Effects on groundwater are classified in terms of four attributes (see Table 4-1):

- direction
- magnitude
- geographic extent
- duration

Combined effect attributes are used to determine if an effect is significant. See EIS Volume 5, Section 4 for a detailed description of effect attributes.

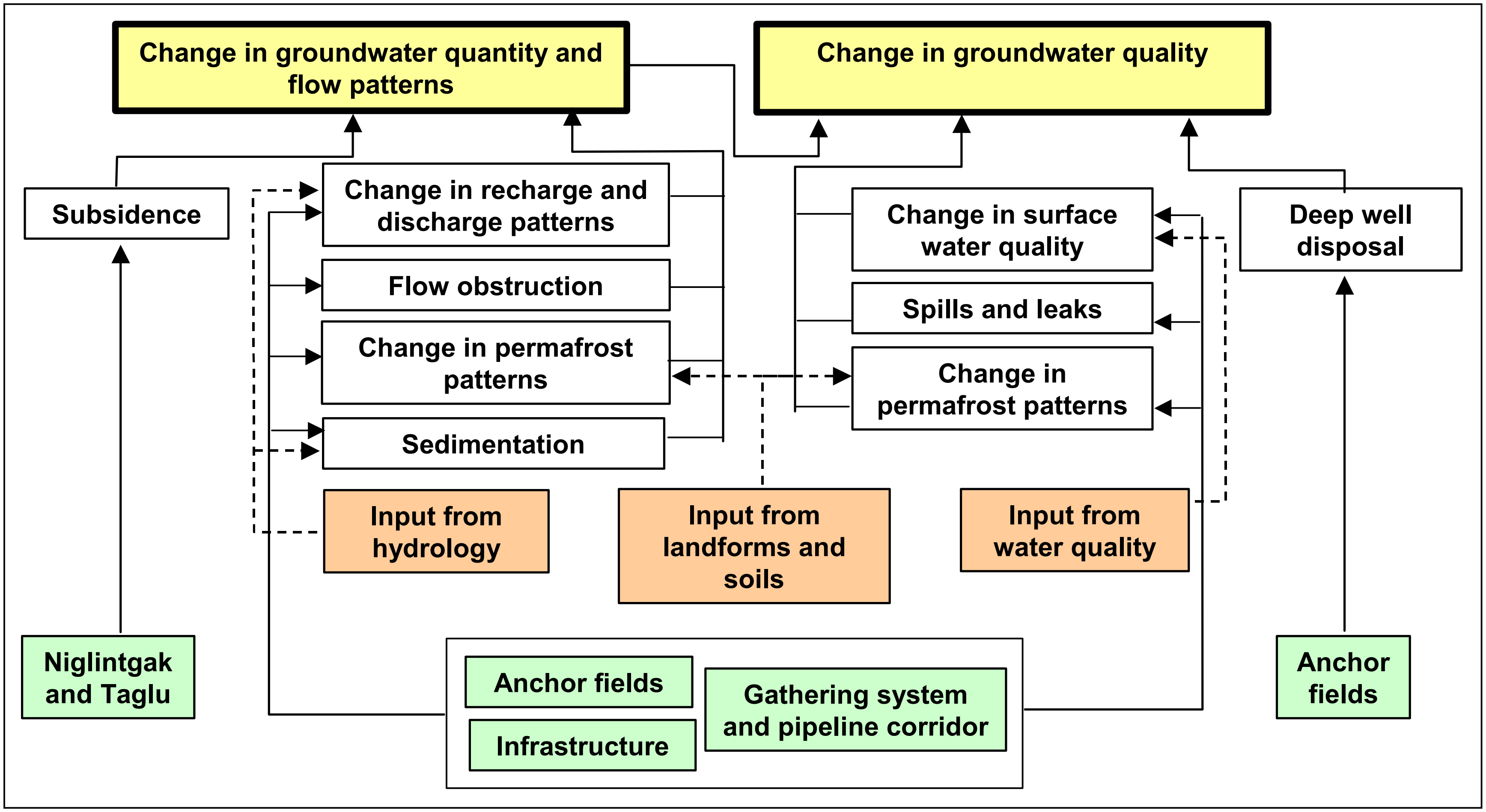

Figure 4-2: Effect Pathways – Groundwater

Table 4-1: Definitions of Effect Attributes for Groundwater

Attribute	Definition
Direction	
Adverse	Effect leading to a change in groundwater quantity, flow patterns or quality
Neutral	No change in groundwater quantity, flow patterns or quality
Positive	Not applicable
Magnitude	
No effect	No effect on groundwater quantity, flow patterns or quality
Low	Effect on groundwater quantity, flow patterns or quality expected to be within normal variation
Moderate	Effect on groundwater quantity, flow patterns or quality predicted to be outside normal range of variation, but unlikely to pose a serious concern or management challenge
High	Effect on groundwater quantity, flow patterns or quality predicted and likely to pose a serious concern or management challenge
Geographic Extent	
Local	Effect on groundwater restricted to local study area
Regional	Effect on groundwater restricted to regional study area
Beyond regional	Effect extends beyond the regional study area
Duration	
Short term	Effect on groundwater continues for less than one year
Medium term	Effect on groundwater continues for a period of one year to four years
Long term	Effect on groundwater continues for more than four years but not more than 30 years after abandonment and decommissioning
Far future	Effect on groundwater continues for more than 30 years after abandonment and decommissioning

Analysis and Significance

Groundwater Quantity and Flow Patterns

Construction

Local alterations in surface drainage patterns could result in small changes in shallow groundwater flow patterns. Similarly, changes in surface water levels could affect recharge to groundwater and groundwater quantity. Effects on surface water drainage patterns and water levels are expected to be low magnitude (see Section 5, Hydrology).

The potential for effects through the recharge and discharge pathway related to the development of slides is considered low, primarily because of the subdued topography in this area. The route selection process avoided these areas. Monitoring pipeline integrity during operations, including aerial inspections, would identify any slide development and enable engineering response to manage effects.

Ditching could obstruct or divert subsurface groundwater flow. Installation of subdrains or ditch plugs in areas where groundwater flow is encountered during ditching should reduce any effects related to flow obstruction in most settings. Effects related to flow obstruction are expected to be low magnitude. Effects of flow obstruction related to the physical presence of the pipeline in the subsurface would continue into the far future, unless the pipeline is removed during decommissioning and abandonment.

Surface facilities will be located at a site where permafrost is not present, so changes in permafrost conditions are expected to be low magnitude. If necessary, surface facilities can be thermally separated from the ground. Minor, undetectable effects on groundwater quantity and flow patterns are expected during construction and operations.

Operations

Potential subzero temperatures in the pipeline could create a frost bulb in areas of unfrozen ground. The frost bulb could form a barrier to downgradient movement of groundwater, and in some cases, this obstruction could be sufficient to force groundwater to the surface. Where moderate groundwater flow passes through a confined area of high permeability underneath the stream bed, the pipeline, with or without a frost bulb, might be a sufficient barrier to subsurface water movement and could also result in forcing groundwater to the surface. Deep burial or insulation of the pipeline at selected crossings will reduce the residual effect of this pathway to low magnitude, and address icings or substantial groundwater blockage.

Watercourse crossings where frost bulb mitigation measures are not applied, and any cross-slope areas, could experience effects of moderate to high magnitude. Monitoring for frost bulb development would enable an engineering response to manage effects. The pipeline will return to ambient temperatures following decommissioning and abandonment. Effects would be long term.

Effects related to flow obstruction initiated during construction could persist into the far future where the pipeline is abandoned in place. Operations effects will be long term. Effects on groundwater quantity and flow patterns are not significant (see Table 4-2).

Groundwater Quality

Changes in surface water quality are expected to be within the range of normal variation, i.e., low magnitude, during construction and operations. Therefore, any effects on groundwater quality via this pathway are expected to be low magnitude. Given the slow rates of groundwater movement expected in this area, it is possible that changes in groundwater quality could persist for a long time in the groundwater system. After operations cease, it is expected that surface water quality, and subsequently groundwater quality, would still be within the range of normal variation.

Table 4-2: Effects on Groundwater

Valued Component	Phase When Impact Occurs	Effect Attribute				Significant
		Direction	Magnitude	Geographic Extent	Duration	
Groundwater quantity and flow patterns	Construction	Adverse	Low	Local	Far future	No
	Operations	Adverse	Low	Local	Long term	No
	Decommissioning and abandonment	Neutral	No effect	N/A	N/A	No
Groundwater quality	Construction	Adverse	Low	Local	Long term	No
	Operations	Adverse	Low	Local	Long term	No
	Decommissioning and abandonment	Neutral	No effect	N/A	N/A	No

NOTE:
N/A = not applicable

Effects on permafrost are expected to be low magnitude, so any changes in groundwater quality through this pathway are expected to be undetectable. These changes would be initiated during construction and operations, and groundwater quality would recover to baseline conditions following decommissioning and abandonment. Effects on groundwater quality are not significant (see Table 4-2, shown previously).

Prediction Confidence

Because of the precautionary approach used to predict effects on groundwater, there is a high degree of confidence in the assessment of significance of effects. The level of confidence is consistent with that in EIS Volume 5, Section 4.

Combined Project Effects

This assessment of effects on groundwater from the Vardie River Section indicates that effects from construction of the pipeline will be adverse, low magnitude and local. Depending on the VC being assessed, effects could persist for the long term or into the far future.

The EIS concluded that the Mackenzie Gas Project in combination with NGTL's Dickins Lake Section would produce no significant effects on:

- water quality and flow patterns
- water quality

This assessment for northwestern Alberta concludes that the Mackenzie Gas Project combined with NGTL's Dickins Lake and Vardie River sections will also produce no significant effects.